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THE COUNTERACTANCE MODEL[1]

STUART CARTER DODD

ABSTRACT

The proposed model operationally defines "counteractance" in three tenses by formulas specifying: how to identify it in fitting harmonic curves (i.e., $y = k/x^e$); how to produce it from preconditions of two measurable and opposed interactions where everyone has equal opportunity to interact; and how to predict in such situations. In four controlled experiments in series of towns an interaction in the form of the diffusion of a message was found with excellent fits to vary inversely with powers of four counteracting factors when isolated in turn, namely: the distance between interactors; the time sequence of interacting; the population size of interactors; and increments in stimulation.

The four pieces of research reviewed here were undertaken in order to learn more about how to describe and predict some mass activity with a resistive factor within it. The counteractance model was explored as part of a program of systematic exploration of dimensional formulas. The partly a priori and partly *ex post facto* analyses reported here aimed to find out more exactly what forms and amounts of resistance would fit models with negative exponents.

This model grew from at least three roots. An empirical root lay in two groups of studies,[2] those on interaction showing an inverse relation to the distance intervening between interactors, and the studies of the size-rank rule in its diverse manifestations.

A second root, partly empirical, partly theoretical, came from the desire to test our hunch[3] that the logarithmic Weber-Fechner formula[4] in individual sensory psychology would apply to the stimulation and responding of whole communities. This logarithmic formula can be re-expressed in uncumulative form as the product of two variables equaling a constant, k, i.e.,

$$X^eY = k \qquad (1)$$

(the generalized hyperbola or harmonic series [in algebraic form]).

This is the simple hyperbola when the weighting exponent, e, is 1 and becomes the generalized hyperbola for other positive values of e. This formula for the constant product of two variables fitted a preliminary set of data when four communities were stimulated by airborne leaflet drops. So this harmonic series, equation (1), in its cumulated or log form was hypothesized as a model for such stimulus-response situations in communities.

A third and theoretical root was the dimentional analysis or S-system which was being developed into one of its special and predictive submodels called the "transact

[1] This research was supported in part by the United States Air Force under Contract AF 33(038)-27522, monitored by the Human Resources Research Institute (now Officer Education Research Laboratory, Air Force Personnel and Training Research Center), Air Research and Development Command, Maxwell Air Force Base, Alabama. Permission is granted for reproduction, translation, publication, and distribution in part and in whole by or for the United States government.

[2] Joseph A. Cavanaugh, "Formulation, Analysis, and Testing of the Interactance Hypothesis" (unpublished Ph.D. thesis, University of Washington, 1950); Peter C. Dodd, "Social Physics: Theory and Applications of Demographic Gravitation" (unpublished thesis, Princeton University, 1950); Stuart C. Dodd, *Dimensions of Society* (New York: Macmillan Co., 1942), pp. 944; W. J. Reilly, *Method for the Study of Retail Relationships* (University of Texas Bull. 2944 [Austin, 1929]); J. Q. Stewart, "Demographic Gravitation: Evidence and Applications," *Sociometry*, Vol. XI, Nos. 1 and 2 (February–May, 1948); S. A. Stouffer, "Intervening Opportunities: A Theory Relating Mobility and Distance," *American Sociological Review*, V (December, 1940), 677–86; G. K. Zipf, *Human Behavior and the Principle of Least Effort* (Cambridge, Mass.: Addison-Wesley Press, 1949), chap. ix.

[3] Stuart C. Dodd, "Testing Message Diffusion from Person to Person," *Public Opinion Quarterly*, Vol. XVI (Spring, 1952).

[4] J. P. Guilford, *Psychometric Methods* (New York: McGraw-Hill Book Co., 1936), p. 139.

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mode."[5] This six-dimensional *S*-formula for any "transaction" (defined as any action-in-explicit-context) factored any human action and its context into six factors capable of being standardized, or classes, of variables. It analyzed transactions as an algebraic product (which means socially "a joint occurrence") of *acts* (A) of *people* (P) in *time* (T) and *space* (L) for ends or *values* (V) and with means or residual *circumstances* (C).

These reliably observable and always present factors of human behavior answer the universal questions: "Who does what?" "When and where?" "Why?" and "How?" When this formula, capable of describing any behavioral situation whatever, was formally expressed as a product of these six major dimensions, each weighted or developed by an exponent, it became the formula for a hypothesized behavior ($=B_h$), namely:

$$B_h \overset{\text{def.}}{=} A^a P^p T^t L^l V^v C^c \qquad (2)$$

(the "transactance" model [in dimensional form]).[6]

Whenever any one of the six factors is isolated (making the exponents of the other five factors zero), and whenever the exponent on the isolated factor, X, is negative (expressing a resistive factor), this transact formula simplifies to the special case of the hyperbola which is our counteractance model, namely:

$$B_h \overset{\text{def.}}{=} X^{-e} \qquad (3)$$

(the "one-factor" counteractance model [in dimensional form])[7]

and

$$B_o = ? \; X^{-e} \text{ or } r_{ho} \overset{\text{hyp.}}{=} 1.0 \qquad (3A)$$

(the counteractance hypothesis of high correlation between the behavior, as hypothesized, B_h, and as observed, B_o).

These three roots of the counteractance model grew vigorously when nourished by an Air Force contract to develop general principles (expressed in mathematical models) for diffusing messages by means of dropping airborne leaflets: "Project Revere." It proved admirably adapted for basic experimental research on human interaction, since it gave the research worker a high degree of control of his stimulation of both individuals and whole communities and of his measurement of their responses and the factors of their context. We selected the diffusion achieved as the criterion variable to be predicted and maximized. We defined diffusion most simply (among many indices tried) as the percentage of persons knowing the leaflet message, and this was determined either by interviewing a probability sample of residents in the locality three days after the leaflets were dropped or by tracer stubs torn off the leaflets and mailed back.

Project Revere contrived situations as experiments with varying cleanness of controls. These tests were designed to measure the form, amount, and statistical significance of the dependence of the observed diffusion transact, B_o, upon its six factors, each isolated in turn. Of the six, the four reported below were observed under certain conditions to vary inversely with the diffusion. Consequently, the four factors of distance, time, population, and stimulation strength are brought together here in order to illus-

[5] Stuart C. Dodd, "The Transact Model—A Predictive and Testable Theory of Social Action," *Sociometry*, December, 1955.

[6] This set of six "factors" developed, as explicitly expected by us (*Dimensions of Society*), out of the four "sectors" of "time," "space," "people," and "all else" (I) by subclassifying the indexes of the residual sector (I) into the compound or non-elemental categories of "acts," "values" (i.e., desiderata), and a reduced residual category called "circumstances" (C). The smaller non-overlapping set of four categories, the sectors, is best for rigorous logical analyses. The six factors of the larger set have more overlap between them but are very useful for practical purposes in describing social phenomena.

[7] For the differences between dimensional and statistical forms of formulas see Dodd, *Dimensions of Society;* Dodd, "The Transact Model . . . ," *op. cit.*; and works cited in nn. 9 and 10 below.

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trate and contribute to delimiting, and in some cases to testing, a general counteractance model.

Algebraically, the counteractance model signifies: The product of two variables (X, Y in eq. [1] or X, B in eq. [3]) is constant, or each varies inversely with the other (when their exponents are 1). Exponents on X and Y other than 1 say further that the two variables may have any relative weighting as specified by the ratio of their exponents. If for convenience' sake we take any exponent on Y as unity and let the exponent on X vary accordingly, we have an exponential ratio of $e/1$ or just e.

Socially, the formula states: These symbols represent a closed system in which there are just two relevant variables related as follows: (1) they interact with equal opportunity; (2) they counteract each other; (3) they may act unequally; and (4) their result or end action is constant throughout the situation studied. These relations which are assumed and expressed in equation (1) are the social preconditions that are hypothesized to exist whenever the model is used or tested. Insofar as this model fits given data, it means that these four preconditions tend to exist, fully and solely, in those data.

WHAT FACTORS FIT THE COUNTERACTANCE MODEL

Among the twenty-seven series of tests in Project Revere the counteractance model was observed to fit four of the six factors of a transact.[8] (A "transact" here denotes any transaction when observed in all-or-none form.) When all factors but one were controlled to a high degree, the diffusion of a leaflet message was found to tend to vary inversely in turn with (1) the distance between interactors; (2) the sequence of interacting; (3) the number of interactors; and (4) the increments in the stimulation to interact.[9] To review the four experiments briefly:

Distance.—The dependence of the diffusion transact or one-way interact in a population upon the distance across which the message diffuses was isolated and measured in one community as follows: We launched a six-word message—a coffee company's new slogan—in a town of 905 inhabitants one Monday morning by ringing the doorbells of a 20 per cent probability sample of the 303 dwelling units. The interviewers in "Operation Coffee" told the slogan to each housewife in the sample, suggesting that she could do her friends a good turn by repeating it to them. The interviewers promised to deliver a free pound of coffee to every housewife who would know the slogan when they would call at every household on Wednesday. The slogan spread to 82 per cent of the housewives. The distribution of the distance between the homes of each teller and her hearers was a close fit to the waning curve hypothesized by the hyperbola or "inverse distance" formula as shown in Figure 1L. The small discrepancies representing the deviations of the observed data from the model are attributable to sampling fluctuations, as they were not significant by the chi-square test: $p(\chi^2) = .85$. In these data, then, isolating and measuring the distance factor showed almost perfect dependence of the transact upon it. The correlation of the amount of diffusion with the inverse intervening distance was as near perfect ($r = .997$) as behavioral scientists may hope for. This curve, defined by equation (1) or (3), was later christened a spatial subcase of the "counteractance" model.

This extremely high correlation evidences and was made possible by a high degree of control over the other transact factors in "Operation Coffee." The act of retelling the slogan and the react of hearing it were suffi-

[8] Stuart C. Dodd, "Diffusion Is Predictable—Testing Probability Models for Laws of Interaction," *American Sociological Review*, Vol. XX, No. 4 (August, 1955).

[9] For fuller account cf. Stuart C. Dodd, E. D. Rainboth, and J. Nehnevajsa, "Revere Studies on Interaction" (to be published). For a report on "Operation Town Size" see S. C. Dodd, "A Power of Town Size Predicts Its Internal Interacting," *Social Forces*, 1957 (in press).

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ciently similar for all tellers to have introduced not even 1 per cent of attenuation in the correlation. The time available to the starters was about the same for all of them. The motivation was identical—a pound of coffee to each friend—however much individuals varied in appreciating it. The size of population was constant at 303 housewives throughout the two days of the experiment. The usual galaxy of other known and unknown circumstances in a community were present, of course, but they are proved not to be correlated with the diffusion and the distance, or at least to cause no disturbing effects upon the diffusion-distance relation by the following observed fact: *The combination of all variables other than distance here produced only six-tenths of 1 per cent of error of estimate* (i.e., $k^2 = 1 - r^2 = 1.0 - .997^2 = .006$), when estimating the transact from the distance factor via their regression equation.

The distance was only an easily observed index of the counteraction, which was here

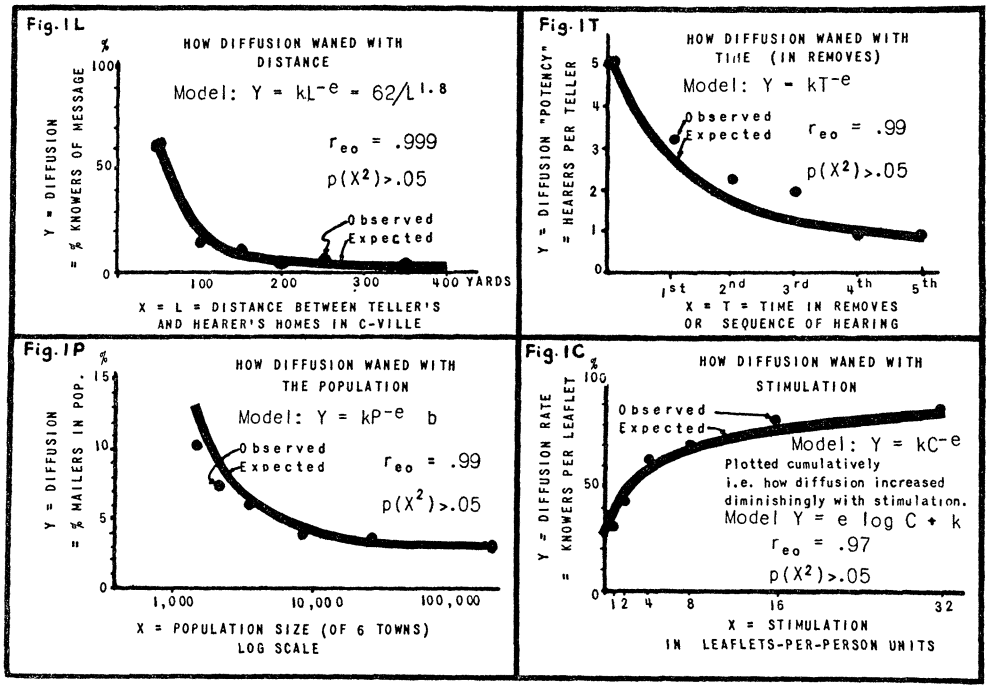
Fig. 1L
HOW DIFFUSION WANED WITH DISTANCE
Model: Y = kL^-e = 62/L^1.8
r_eo = .999
p(X²)>.05
Observed
Expected
Y = DIFFUSION = % KNOWERS OF MESSAGE
X = L = DISTANCE BETWEEN TELLER'S AND HEARER'S HOMES IN C-VILLE
Fig. 1T
HOW DIFFUSION WANED WITH TIME (IN REMOVES)
Model: Y = kT^-e
r_eo = .99
p(X²)>.05
Y = DIFFUSION "POTENCY" = HEARERS PER TELLER
X = T = TIME IN REMOVES OR SEQUENCE OF HEARING
Fig. 1P
HOW DIFFUSION WANED WITH THE POPULATION
Model: Y = kP^-e b
r_eo = .99
p(X²)>.05
Y = DIFFUSION = % MAILERS IN POP.
X = POPULATION SIZE (OF 6 TOWNS) LOG SCALE
Fig. 1C
HOW DIFFUSION WANED WITH STIMULATION
Model: Y = kC^-e
Plotted cumulatively i.e. how diffusion increased diminishingly with stimulation.
Model Y = e log C + k
r_eo = .97
p(X²)>.05
Y = DIFFUSION RATE = KNOWERS PER LEAFLET
X = STIMULATION IN LEAFLETS-PER-PERSON UNITS

FIG. 1.—The counteractance model-fitting message diffusion data to four factors of its context. The generalized harmonic series or hyperbola defined by $Y = kX^{-e}$ was observed in Project Revere to fit as specified below, the dependence of the diffusion ($= Y$) of a leaflet message upon each of its four factors ($= X$) in turn. The factors were: in Fig. 1L the *distance* (i.e., $X = L$) between interactors; in Fig. 1T the *time* (i.e., $X = T$) between interactings; in Fig. 1P the *population* (i.e., $X = P$) of interactors; and in Fig. 1C the *circumstance* (i.e., $X = C$) of amount *of stimulation* to interact. The excellent fits here show that diffusion waned with distance and time, with the log of the population, and with increments of stimulation.

This counteractance model is a special case of the dimensional transactance formula (see S. C. Dodd, "The Transact Model," *Sociometry*, December, 1955), viz.:

$$B_e \overset{\text{def}}{=} A^a\, p^b\, T^t\, L^l\, V^v\, C^c,$$

where the behavior-in-context, B_e, as expected or predicted, is defined as an exponentially weighted product of six factors, i.e., the acts (A) of people (P) in time (T) and space (L) for ends or values (V) and with means or residual circumstances (C). The counteractance submodel isolates any transact factor (X) in a closed system where that factor counters or resists the transacting, as shown by a negative exponent.

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the resistive behavior or effort required as "a cost" in telling the slogan to a friend. Of the total effort to tell evoked in those housewives by the interviewers' promise, part of the effect was manifest in the amount of telling achieved, while another unmanifest part of the total effort was absorbed or canceled out or counteracted by the distance each teller had to walk. (There was no driving or bicycling in this little town of a few hundred yards' diameter. The 5 per cent who telephoned the slogan are not included in the data.) Since the ergs of physical energy spent in walking are fairly proportional to the distance walked, that distance measured well the unmanifest and consumed effort which "counteracted" some of the diffusing.

This experiment adds strong evidence toward confirming the inverse distance subform of the counteractance hypothesis or model. By this model or hypothesis we predict, for further test, that if distance measures resistance or countering action (here presumably effort) to the mass interaction studied; and if the amount of the total interaction at issue (defined as of one kind in one population in one period and area for constant motivation and residual circumstances) is constant (or can be treated so by measuring it as a base for percentages); and if the interaction and the countering action are isolated so as not to be correlated or "overlaid" by other variables, then the amount of the interaction will tend to vary inversely with a power of the intervening distances, i.e., equation (3) will fit the facts.

A social "law of inverse distance," when it becomes eventually more exactly delimited and confirmed, will probably say in effect: *If other factors are constant, interacting wanes with a power of the distance between the interactors.* This is the distance-with-a-

TABLE 1

DIFFUSION RELATED TO FOUR OF ITS FACTORS

TABLE 1L

DIFFUSION AND DISTANCE IN A TOWN OF 905 POPULATION

Distance (50-Yard Units)	Diffusion ("Social") (= % Pop. Hearing) Expected (h)	Observed (o)
1	61.9	61.9
2	17.8	14.2
3	8.6	9.5
4	5.1	4.8
5	3.4	4.8
6	2.5	2.4
7	1.9	2.4

$r_{ho} = .997$ $p(\chi^2) > .85$

TABLE 1T

DIFFUSION AND TIME

Removes	Diffusion Potency (= Mean Hearers per Teller) Expected	Observed
0	5.12	5.12
1	2.56	3.20
2	1.71	2.36
3	1.28	2.00
4	1.02	1.00
5	.85	1.00

$r_{ho} = .99$ $p(\chi^2) > .05$

TABLE 1P

DIFFUSION AND POPULATION IN SIX TOWNS

Town Population	Diffusion ("Social and Physical") (= % Pop. Mailing Back) Expected	Observed
1,304	13.1	10.3
2,013	9.58	7.3
4,150	6.24	6.1
8,430	4.65	4.0
34,600	3.48	3.9
325,994	3.14	3.1

$r_{ho} = .99$ $p(\chi^2) > .05$

TABLE 1C

DIFFUSION AND STIMULATION IN EIGHT MATCHED TOWNS

Leaflet Ratio (=Stim.)	Diffusion ("Social and Physical") (= % Pop. Knowing Message) Expected	Observed
1/4	25.2	25.2
1/2	34.0	37.4
1/1	42.9	30.1
2/1	51.7	44.1
4/1	60.6	63.4
8/1	69.4	71.8
16/1	78.3	82.4
32/1	87.1	87.9

$r_{ho} = .97$ $p(\chi^2) > .05$

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negative exponent L^{-1} part of our transact model equation (2) and of our all-inclusive dimensional model.[10]

Time.—The dependence of the diffusion transact upon the time during which it transpires was isolated and measured in the same community as follows: On Wednesday each housewife was asked to identify who told her the coffee slogan, where, and when. From these replies the growth of the diffusion, or percentage in the town who knew the message, was determined in both ordinal and cardinal units of time. In cardinal units of clock minutes and hours the daily rhythms of eating, working, recreating, and sleeping interfered with observing any regular curve of growth for the person-to-person diffusing of the message. But in ordinal units of the order or sequence of passing it on (at one, two, three, etc., removes from the starter), the data showed more regularity. The removes were uncorrelated with the daily rhythm and so canceled it out or controlled its effect. The regression of the ordinal time index upon the cardinal time was a straight line.

When the potency rate of diffusion, defined as the "first hearers" per teller per remove, was computed, we discovered a previously unsuspected effect. As shown in Figure 1T, the potency rate tended to wane harmonically, varying inversely with the time in remove units. Again the fit of the hyperbola or counteractance model to these time data was good (Fig. 1T). The correlation coefficient of observed and theoretic points was .99, and the discrepancies were not significant by the chi-square test at the 5 per cent level.

Time in ordinal units was well isolated from the other factors or uncorrelated with them. The removes were observed to be uncorrelated with distances. As above, the interact, the stimulation and motivation of it, and the population of the town were all constant or alike for everyone as far as observable during the forty-eight-hour experiment. A correlation of .99 means that other factors could account at most for 2 per cent of the variance as an error of estimate in the regression equation (i.e., $k^2 = 1 - r^2 = 1 - .99^2 = .02$).

The finding that the potency rate or activity rate in diffusing tended to vary inversely with time, though unexpected in the first exploratory test, was supported in a dozen other tests in Project Revere. The harmonic logistic model—which includes the factor of a harmonically waning activity rate—proved by far the model best fitting the growth of diffusion throughout a dozen diverse testings.[11] Consequently, we now expect the potency rate for an interaction, when set off by stimulation at one point in time, to wane in general, and we have developed three mechanisms or hypotheses to explain the harmonic form of such waning and are now testing them in further experiments.

The hypotheses to explain the harmonic waning potency are the overlaying, the drop-out, and the rebuffing effect. The overlaying effect means that an average event in one period will in general be overlaid by n other average events after n periods and so likely to get only $1/n$th of the public's attention in the nth period. The public's activity relative to a past event will then probably wane, i.e., will vary inversely, with the elapsed time. The relative strength or interest of the succeeding events compared with the initial stimulus is measurable by the exponent in equation (1) or (3) when the factor X represents time ($X = T$).

The drop-out effect hypothesizes that individual differences of interest in retelling the message result in the less-interested persons dropping out of the telling group first. This means a waning number of tellers as time goes on and so a waning total rate of telling. The persons least interested may be thought of as having more "overlaying" in-

[10] Stuart C. Dodd, *Systematic Social Science* ("American University of Beirut, Social Science Series," No. 6 [Beirut, 1947]), pp. 785 (University Bookstore, Seattle, Agents). Cf. Dodd, *Dimensions of Society.*

[11] Stuart C. Dodd, "Testing Message Diffusion in Harmonic Logistic Curves," *Psychometrika,* Vol. XXI, No. 2 (June, 1956).

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terests in other matters, so that their progressive ceasing to retell can also be seen as due to competition with other activities.

The rebuffing effect hypothesizes the same result but by a more social mechanism. It proposes that people do less and less telling in proportion as they are rebuffed by hearers who interrupt, saying they have already heard the message. Such rebuffs will increase with an increasing proportion of message-knowers, and this, in turn, increases with time. So rebuffs may be a counteraction which makes diffusing wane with time. And, of course, all three mechanisms, which counteract the diffusing with time, may operate jointly. Further experiments, testing models which isolate the overlaying, individual differences, or rebuffing effects, can delimit the shares of each mechanism in turn under its special preconditions.

Whatever the more specific nature of the separate or joint counteracting mechanisms may prove to be, we hypothesize that if time since an event measures some counteraction to the interaction of people relative to that event, and if that total interaction is constant in amount or can be treated so, and if, as usual, other factors are either constant or uncorrelated so that the time factor can be observed in isolation, then the interaction at issue will tend to vary inversely with a power of the elapsed time. Then equation (3)—with time as the counteractant index—will fit the facts, i.e., $B_o = T^{-e}$. More simply, we expect a social "law of inverse time"—to be confirmed through research by others—as follows: *If other factors are constant, interacting of people about a past event tends to wane in proportion to a power of the time elapsed.*[12] We believe that this model will fit data better and better according as all the factors are better isolated, measured, and controlled.

Population.—This hypothesis had its inception during Project Revere in the test on six towns called "Operation Town Size." The results described here grew out of this exploratory treatment of data gathered in other experiments rather than from a model designed to test the hypothesis rigorously in a new situation (as was the case with the inverse distance hypothesis above, which had had empirical roots in previous studies, already referred to, and the inverse time hypothesis where the unexpected finding in the exploratory test situation was supported by later tests in Project Revere itself). Consequently, we present this hypothesis with only that degree of assurance which cleanness of results in an initial study permits.

The dependence of the observed diffusion transact, B_o, upon the size of the interacting population was isolated and measured in Project Revere as follows: One leaflet per person was dropped comparably by planes on six communities whose population varied from 1,300 to 326,000. The total response mailed back as shown in Figure 1P fitted the counteractance model excellently. The correlation coefficient between the observed data and the harmonic curve (with an exponent of -1) was .99. The chi-square test of the discrepancies was not significant at the 5 per cent level.

For control of the five transact factors in equation (2) other than population, we note that the act of mailing back, its stimulation and motivation, and the time allowed for it were the same for all six communities. Distance was well controlled, since the plane spread the leaflets as evenly as possible over the whole area of each community so all the people could pick up leaflets at about the same distances from their doorsteps.

To explain the observed fact that the percentage diffusion varied inversely with the population, we propose a "counteractive interstimulation" subhypothesis (a hypothesis as to mechanism). The explanation by interstimulation proposes that, the larger the towns, the more the increase in average daily stimulation of all sorts playing on each person will outstrip the increase of population. If the interstimulation of people were

[12] We expect this harmonic rule to hold also for future or anticipated events where preparatory interaction tends to increase as the event gets near. Thus, in general, this hypothesis is: Interaction about a past or future event tends to vary inversely with the intervening time, when other factors are constant.

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in pairs only, it would increase up to a theoretic ceiling proportional not simply to the population but to its square. This square is a theoretic upper limit for pair interaction, since everyone cannot interact daily and directly with everyone as cities get large.[13] Now the stimulation of the leaflet was constant in per capita size for all towns. Consequently, the ratio of stimulation by the leaflet to total stimulation on each person would shrink as size of city was greater. The stimulation of the leaflet varied among towns exactly as the first power of the population; the total interstimulation of people in pairs, we argue, would increase at more than the population rate of growth and perhaps approach the square of the population; their ratio indicating the share of the public attention commanded by the leaflets should vary at most as the inverse first power of the population, i.e., $P/P^2 = P^{-1}$. The fit was tried for each tenth of a point of the exponent and found to be about equally good from $P^{-.7}$ to $P^{-1.0}$.

The larger populations generate more interstimulation than the smaller, and the enlarged total stimulation competes with the stimulation of the leaflet and counteracts some of the potential responses mailed back. The relative response to the leaflets in small and large towns is reflected in the small towner's excited narrative when planes rained leaflets on his town—as compared with blasé metropolitan comment, "Uh huh, just another advertising stunt."

Consequently, though more tentatively than for previous factors, the third factor's relation to a transact is formulated as follows: If population size measures some counteracting factor—perhaps total interstimulation—and if other factors are constant or uncorrelated, then the partial interaction per capita at issue will tend to vary inversely with a power of the population. Then equation (3), rewritten for the population factor, $B_o = P^{-e}$, will fit the facts. This hypothesis if confirmed would become the social "law of inverse population." It might be roughly: *If other factors are constant, the interaction per person about some stimulus, constant per person from town to town, wanes with larger populations.*

Increments of stimulation.—For the fourth set of experimental data, the dependence of the diffusion transact upon the increases in stimulation was demonstrated in the test called "Operation Leaflet Ratios." Leaflets were comparably dropped on eight matched small towns. The number of leaflets was doubled from town to town in the series, rising from one leaflet to every four persons to thirty-two leaflets per person in the eighth town. As the stimulation of these communities rose in geometric ratio, their responses were observed to rise in arithmetic ratio, as had been hypothesized. Each doubling of strength of stimulation yielded about nine percentage points of increase in the community response measured by the percentage of knowers of the message. This logarithmic relation of stimulation to response fitted the observed data well. The correlation coefficient between the log model and the observed diffusion was .97, with non-significant discrepancies by chi-square test at the 5 per cent level. The log curve is the cumulative or integrated form of the hyperbola (for continuous data which are approximated by the discrete harmonic series or inverse natural numbers: 1/1, 1/2, 1/3, 1/4, . . ., $1/N$). It is the counteractance model again as graphed in log form in Figure 1C.[14]

Again, in this test one transact factor –a circumstance—was isolated, varied under control, and its effect measured. Again, the other five transact factors were held fairly constant by selecting matched towns and by giving them identical treatment except for controlled varying of the one factor at issue.

[13] Further increased interacting in larger groups than pairs, owing to more roles and more symbolic mediation in cities, would increase the interstimulation by amounts at present unknown.

[14] In harmonic form the fit is looser than in the cumulated or log form reported above. As figure 1C pictures, one town showed a negative instead of the expected positive increment compared with the previous town in the series. The Weber-Fechner principle is erratic at the extremes such as below one leaflet per person, apparently. But, aside from the extremes, the fit of the harmonic curve is excellent.

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For interpretation, one asks how is it possible that increasing the stimulation can counteract the response? The answer is that the absolute response increased but increased diminishingly (Fig. 1C). As the number of leaflets increases, each evokes a smaller *share* of the total response of a community. Proliferating leaflets appear to compete with each other, reducing the share of each in the diffusion produced. Thus, the more leaflets, the more some of the effect of each is counteracted.

Consequently, the relation of this fourth factor constituting a circumstance in a transact, much as in the cases of the other three, is stated as: If increasing stimulation evokes a decreased rate of interactive response, if that total responsive interaction is measurable, and if other factors are constant or uncorrelated, then increments of the interaction at issue will tend to vary inversely with some power of the stimulation.

As far then as we can now state it, the upshot seems to be an eventual social "law of inverse stimulation": *Insofar as other factors are constant, per capita increments of reaction between lower and upper bounds of reaction wane with the amount of stimulation of one kind.*

The hypotheses.—With these four sets of well-fitted data before us (Fig. 1), let us examine more closely the set of counteractance hypotheses as candidate laws for sociology. The counteractance model may be thought of as an operationally defined theory comprising five aspects, or a main hypothesis with five subhypotheses. Each of the five asserts one precondition or assumption; taken together, they specify the model, which is a statement of a theory in explicit and testable terms.

The main "counteractance hypothesis" proposes that the model, equation (1), will fit closely and surely the observed data (insofar as the observations were made under the preconditions specified in the model, of course). This summary hypothesis is tested by the degree of closeness and sureness of the fit. How closely and with what probability does the theory agree with the facts? A descriptive index such as an appropriate form of correlation index, r_{ho}, can measure the closeness of fit of the observed and expected variables (i.e., the data in hand and the model). A probability index from sampling statistics, such as the chi-square test for the significance of the observed discrepancies from the model, can measure the sureness of the fit. To apply these tests, the "counteractance" index, B_h, defines the behavior as expected by the product of the six factors as in equation (2). Then the "counteract" index, B_o, denotes the behavior as observed which serves to validate or invalidate the hypothesis. One may then say: The formula describes and may be expected thereafter to predict such behavior under those preconditions.

The five hypotheses specify the five assumptions implicit in the counteractance formula, equation (1). These are:

1. *Countering.*—The two variables, X and Y, are inversely related to each other ($X = 1/Y$) and so have perfect negative, curvilinear correlation. Socially, this means the two indexes are completely opposite or in full conflict as in representing an act (Y) and a counter to it or resistance (X). The countereffect, whatever its cause, may be very indirectly measured by some observable index such as in our data where distance presumably measured effort to overcome it, time measured perhaps competing events displacing an action, population measured (we hypothesize) distracting stimulation and the response to it, and increments in stimulation may have measured detraction from the share of response produced by each unit of stimulation.

2. *Interacting.*—The two variables algebraically are multiplied together, forming a product (XY), not a sum ($X + Y$). Socially, this represents interaction or joint action where each variable modifies the other and not independent or alternative actions (which may be represented by algebraic sums or logical sums). This means that the product or joint result of the two variables may be a pattern or emergent new whole which is more than the sum of its parts. The effect of the two variables is one unified act—such as telling-a-message-

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in-spite-of-resistance—not an aggregate of acts, such as telling several messages.

An a priori test or "precondition" for this precondition of multiplicative combining of the two variables in equation (1) is the "vanishing-result" test. If any factor in a product vanishes (i.e., = 0), the product vanishes; but an addend in a sum may vanish without wiping out the sum. The four factors of distance, time, people, and stimulation (like all the factors of every transact) *always* satisfy this vanishing-result test. For every transact, every human act, must become non-existent if there is no doer (P), no time (T) or space (L) whatever to behave in, no values (V) or verbalizable wants, and no context (C) whatever, material or symbolic. These factors may vary as four of them did in turn in our data above, or they may be constant at some non-zero amount, of course; but they cannot become absolutely zero if the transact exists at all.

3. *Unequal acting.*—The two variables are algebraically specified by the counteractance model, equation (1) or (3), to have any relative weighting depending on the value of the exponent, e. Socially, this means the act (Y) and its counteract (X) may be of equal or unequal importance and effect. At one extreme, when the exponent is zero, the counteract has no effect on communicating (as in the case of phoning within one exchange area). At the other extreme, when the exponent is infinite, the counteract is all-important and completely prevents the act, as when the Atlantic Ocean, before it was ever crossed, completely prevented any communication across it. In between, when the exponent e is 1, the counteract equals the act in importance—each is half the total activity. This is the case of the simple harmonic series or equilateral hyperbola.[15]

[15] It is also the case of unit elasticity in supply and demand curves in economics. It is the case of a constant demand ($= k$ in eq. [1]) which makes price and supply inverse to each other. The relation of the counteractance model to demand-supply-prices is explored in some detail in Dodd, *Systematic Social Science*, chap. xii.

4. *Definite total action.*—The algebraic product of the two variables is a constant ($XY = k$ in equation [1]). Socially, this seems to mean that there is a definite total amount of relevant behavior or human energy in the situation. This total is (*a*) either constant over all values of the independent or counteracting variable, X, or else (*b*) taken as a base for percentage expression of X and of Y as representing proportions of that variable but definite total of energy. (The proportions must be such that the sum of the logs which represent the two proportions, p, q, is a constant, i.e., $\ln X + \ln Y = \ln k$ or $p + q = 1$.)[16] By this percentage device one can deal with a manifest part, Y, of the total and variable activity, and a second unmanifest and counteracted part, indirectly indicated by X.

5. *Equal opportunity.*—The fifth assumption or social preconditon underlying the counteractance model relates the dimensions of actors to the acts. This relation can be expressed statistically as a rectangular distribution and socially means an equal opportunity or equal probability for each actor to act. Thus it is assumed that, in walking X units of distance, each unit consumes an equal share of the actor's energy. Again, in reacting to stimuli on X successive days in the second set of data, we assume the daily reactions to be about equal, so that after X days each day probably received $1/X$ of the total reactions. Similarly, we assume the reaction per leaflet to be equal for all leaflets dropped in a given operation, i.e., each leaflet has a social opportunity or mathematical probability of being picked up that is equal for all leaflets dropped on the one occasion. This

[16] We speculate here on possible relations between this equation of log proportions and information theory which defines information in terms of logs and probabilities. "Information" ($= H$) is being increasingly linked to the concepts of "organization" and of "negative entropy." Entropy and organization are counteractive tendencies for the universe to run down and to build up. Is it possible that the counteraction equation expresses in primitively simple form the cosmic equilibrium of the organizing forces and the counteractive disorganizing forces within a constant cosmos?

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amounts to taking the average share of opportunity, $1/X$, as the statistical probability, p, that is associated with or represents each leaflet. In the last set of data the equal opportunity was assumed in taking the average or per capita interstimulation in each town as representing each person—for purposes of mass comparisons.

The assumptions are not independent. They have some logical redundancy as in presenting the two factors (X, Y) either as reciprocals or as forming a constant product (i.e., $X = 1/Y$ implies $XY = 1$). But the redundancy may be useful as when, in examining a new situation, certain of the five preconditions turn out to be more observable than others of them, and this helps in deciding on the applicability of the general model and the form in which to observe it.

The five explanatory preconditions seem to depend on form more than content, on the symbolic analysis chosen more than on the phenomena or their "intrinsic nature" —a major tenet underlying all dimensional analysis of which this paper is but another example. The counteractance model brings together behavior of any institutional or other content, provided its symbols are related together as specified by the formula. Re-expressing phenomena by the symbols gives sociologists observable, verifiable, and predictable ways of dealing with phenomena. In fact, all laws in science as such are seen as a search for formal regularities and unification, provided the forms or formulas in turn have one-to-one correspondence to observables.

The five assumptions or social preconditions can be viewed as a "shrinking share" explanation of the simple harmonic series, $1/1, 1/2, 1/3, 1/4, \ldots, 1/N$. . Shrinking shares are easily understood by the instance of slicing a pie: any whole pie when sliced into N equal slices will necessarily give slices of size $1/N$; the more the slices, the smaller they are. The number and size of slices must vary inversely to each other, if the slices are equal. If unequal, one approximates the situation by saying "the number and *average* size of slice are mutually reciprocal." This way of looking at, or "explaining," all cases of data which fit the counteractance model, we have thus far found to be more satisfactory than Zipf's explanation by "least effort"[17] or Simons' by probability.[18] On more vigorous logical analysis the three explanations may prove to be largely differing language statements of the same referent; meantime, the slices of pie offer a fruitful concept. If total distance walked is the "pie," the more the units of distance, the smaller is each unit's slice of total energy. If total reactions in a given time are the "pie," the more days, the smaller will be each day's slice of the total reactions. If total reaction to leaflets is the "pie," the more leaflets, the smaller each slice of reaction per leaflet. If total reaction to all kinds of interstimulation in a town is the "pie," then the more numerous the people and their units of interstimulation, the smaller, relatively, will be each unit slice such as one leaflet per person.

Thus the counteractance model describes and should predict new situations in the future wherever a single total human activity is the joint result, in some ratio, of a manifested part or action (Y) and a resistive part or counteraction (X). This last sentence, summarizing the assumptions in the counteractance model, is more exactly and universally stated in formal algebraic terms by $Y = kX^{-e}$ (eq. [1]).

WHY THE COUNTERACTANCE MODEL MAY BE USEFUL

Model-testing should yield validated models which then become formulas or rules telling social engineers how to pursue their ends by the most efficient means. Thus the model of inverse distance tells

[17] *Op. cit.*

[18] Herbert A. Simons, "On a Class of Skew Distribution Functions," *Biometrika*, Vol. LXII, Parts III and IV (December, 1955). Simons, whose article came to our attention after the original writing of this paper, reports a stochastic and probabilistic analysis which seems compatible with ours. His model seems to us to delineate a mechanism underlying our terms of "counteracting," "interacting," etc.

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the operator how to distribute leaflets to the greatest number of people by plane. Many points, approaching even distribution over a territory, will reach more people than one or a few peaks. The rule of inverse time tells how to schedule dropping leaflets so as to maximize the desired interaction at the desired times. The rule of inverse population tells him how to choose the towns and missions for his planes so as to reach the greatest number of people. The rule of inverse stimulus tells him how many leaflets to drop on a given population with largest probability of reaching most of them with least waste.

All these rules, if confirmed by tests on other sorts of mass reaction, can help build up a body of laws of social mechanics as dependable as those of physical mechanics in its early years.[19] For the counteractance model tested here was not dependent on the particular kind of behavior used in testing it, that is, on the reaction to leaflet messages. Nor is it dependent on the situation, such as that involving civil defense interest in the United States in 1952–53. Nor is it dependent on the American culture or industrial civilization. With local exponents, coefficients, and units, the same *shape* of curve defined by equations (1) and (3), we predict, will recur wherever a definite mass action with a counteracting factor within it is measured in isolation from other factors. It is chiefly, we believe, a matter of sufficient resources for such social research being provided, for such formulas to be extended to more than one counteracting variable, to diverse classes of acts and counteracts, and in diverse contexts of people and purpose, period and place, and attendant circumstances.[20]

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[19] Stuart C. Dodd, "Formulas for Spreading Opinions—a Report of Controlled Experiments on Leaflet Messages in Project Revere," *Public Opinion Quarterly* (in press).

[20] In the long run the immediate and practical uses of the counteractance model, as of any highly general or dimensional model, will be outweighed, we believe, by its methodological and systematizing uses. The counteractance model is a subcase of our powers model, which is a subcase of our transact model, for all social behavior, and this, in turn, is a subcase of our dimensional formula for all symbolizable knowledge. As the counteractance model is verified by other investigators, it will contribute to verifying the dimensional system of sociology. The bit of that system here tested simply isolated the relation of an action to a counteraction as expressed by a negative exponent, eq. (3).

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